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THE TREND OF ASTRONOMY

By R. K. Young

(President's Annual Address, January 17, 1933)

THE crest of the Royal Astronomical Society of Canada bears the legend, "Quo ducit Urania"—wherever astronomy leads us. The words might be freely translated as the title of my lecture this evening. Just as all business concerns find it expedient at the end of the year to take stock, and to prepare an annual statement, research finds it profitable from time to time to pause and survey what has already been accomplished, what problems are at present being attacked and where future energy may be expended to advantage. It has been our custom at this time of year for the Society to devote one evening to such considerations, and it is especially suitable that we should do so this year, because we hope that before another year has passed we shall have an observatory in active operation. The institution will be part of the University of Toronto, but I am sure that it will help the Astronomical Society and lead the members to take a keener interest in astronomy.

The development of new instruments for making observations has played an important part in the advance of astronomy. Early observations made with the naked eye or by means of the crudest of instruments led to the Ptolemaic system, with the earth as the centre of the universe. This seemed the most reasonable hypothesis and it was not displaced for over a thousand years. The observa-

tions of Tycho Brahe, made with the quadrants which he perfected, led Kepler ultimately to the correct motion of the planets, as outlined by Copernicus in his theories somewhat earlier. The invention of the telescope about the beginning of the 17th century, and the discovery of the satellites of Jupiter and the phases of Venus with it, established the Copernian theory beyond all question.

The telescope is correctly considered as the most wonderful invention. A millenium of observations, theories, discussions and calculations had to be modified to fit the observed facts which even the first crude telescopes established. The inventor of a new instrument of observation, which can obtain new and more accurate results than any hitherto obtained, may contribute more to the advancement of the science than centuries of less accurate observations and endless calculations. The telescope has been greatly improved since the time of its invention. In the space of fifty years, we have seen the construction of the 36-inch Lick refractor, the 40-inch Yerkes telescope, the 60-inch reflector at Mount Wilson, the 72-inch reflector at Victoria, the 100-inch reflector at Mount Wilson, and there is planned a 200-inch reflector. Experiments now under way, though rather discouraging at first, give promise of making such a telescope possible.

The improvement in quality has been commensurable with the increase in size. The early telescopes were made with single lenses and did not give good definition. They suffered from chromatic aberration also. Great strides have been made in perfecting optical glass, and the modern refracting telescope gives almost perfect definition over a wide field. A limit has been reached, however, in the size of such an instrument because the lenses have to be reasonably thin to eliminate absorption and internal strains, and the sizes over 40 inches in diameter have a tendency to flex under their own weight. The trend has been to make more and more of the larger telescopes of the reflecting type. This policy has been dictated by the cost, as well as by the fact that chromatic troubles vanish in the reflector. The ideal substance from which to make the largest mirrors remains yet to be discovered. It should be light, very rigid and hard, take a high polish and either have a low coefficient of expansion or else take up the temperature of the surrounding air

quickly. Materials which have been used are speculum, chromium and stellite steel, glass and quartz. At the present time some of the glasses with low heat expansions seem to be the best. The possibilities of steel mirrors have not been fully investigated.

The invention of the photographic process may be placed second in importance to the telescope, and its improvement since the time of its discovery has been almost as striking as that of the telescope. Many of you will remember the old days when you had to remain still for several seconds to have your picture taken. Photographs now can be taken in almost any light in a fraction of a second.

The first astronomical photographs were made about the year 1840, and in 1845 Bond at Cambridge succeeded in imprinting images of Vega and Castor, two first magnitude stars, on a photographic plate. With this effort we may compare recent direct photographs of the nebula in Andromeda showing individual stars a thousand million times fainter. Each succeeding year emphasizes the merits of the photographic process for all quantitative work in astronomy. Science owes a debt of gratitude to the large commercial firms that have spent and are spending millions of dollars in perfecting the dry plate,—in speed, fineness of grain and sensitivity to all wave-lengths. You will realize the great gain to astronomy by the increase in speed of the photographic plate when you consider that to double the speed of the plate virtually means doubling the photographic effectiveness of all existing telescopes in the same ratio. The increase in speed for the red colours is also very important because of all the rays these rays come down to us the least distorted or bent by the atmosphere about the earth. It is now possible to secure photographs of stars and planets using a portion of the spectrum redder than can be detected as light by the eye. With the red rays it may be possible to photograph the corona of the sun without the aid of a solar eclipse. Experiments along this line have already met with some success.

The importance of the development of the instruments for observing in astronomy has been emphasized because more and more we are coming to realize that the eye is an imperfect instrument. There are accessories of the telescope which will be mentioned later in connection with the problems they are designed

to solve. At some future time we may expect that all astronomical observations will rest either on photographic or mechanical registering devices, and that we may have astronomers of the highest rank who have never looked at the stars. The universe seems to be constituted in such a complicated way that its properties can not be directly observed. We can theorize about its constitution only by calculation from quantitative measures of observed phenomena, motions, brightnesses, distances of the stars. Other sciences find the same thing. No one has ever seen a molecule or atom, much less an electron. Their nature is calculated from effects produced. So, too, in astronomy we cannot observe the nature of the stars directly nor determine their nature by looking through a telescope. The great telescopes of the large observatories of the world are not utilized for visual observation. Every available hour from sunset to sunrise is used in more serious work, and if it is found necessary to turn the telescope over for a few hours a week to allow the public to view the planets or the moon, it is done in reply to a popular demand. There has been a concerted effort made, however, in recent years by scientists of all countries to present to the general reader the results of modern science, and the reward has been an ever increasing number of real workers in the field, a wider understanding of the aims of science, a greater appreciation of what has been accomplished, together with very generous financial support. In writing their reminiscences of astronomy many a famous astronomer has recorded that his interest in the subject was first aroused by a view through a telescope. A small telescope very frequently gives a much more satisfactory view of the planets or moon than larger instruments, and as the general understanding of the subject becomes greater there will be less demand to use the largest telescope at any time for visual observation. In addition to the 74-inch reflecting telescope of the David Dunlap Observatory, we hope to have a 10-inch refractor. This latter instrument will be more generally available for visual observation and better suited for the purpose than the large reflector.

Astronomy may be divided into three branches of study. In the first branch I include positional astronomy. It concerns the observations of the positions and motions of the astronomical bodies

whether planets or stars. The second branch may be called physical astronomy and concerns the nature of the bodies themselves. Under this head would be listed the study of variables and the new astronomy called astrophysics. The third branch is theoretical astronomy, which attempts to give the "why" and "wherefore" of things. It has to do with both the preceding divisions which are observational. These divisions are arbitrary and not quite in accord with those found in the texts, but they will serve us in our discussion of the trend of astronomical work.

Positional astronomy was the first to be put on a scientific basis. It may be said to have commenced with the theories of Copernicus, the observations of Tycho Brahe and the deductions of Kepler. Through the 16th, 17th and 18th centuries, it was brought to a high state of perfection through the labours of a long list of distinguished names,—Galileo, Newton, Bradley, Laplace, Lagrange, Bessel and others. By the beginning of the 19th century the mechanism of the solar system had been worked out and Newton's law of gravitation shown to explain completely the motions of the planets. During the same interval the foundations of sidereal astronomy, the determination of the positions and motions of the stars, was laid through the accurate observations of Bradley and Bessel. To astronomers during these centuries it seemed that astronomy of position was the only real astronomy. It seemed impossible to them that we should ever be able to learn much of the constitution or nature of the stars, and this branch of the subject was left more or less to the amateurs. As so often has happened since, the amateur showed the way to the professional, and out of his labours has grown the subject of astrophysics which occupies so much of the attention of the astronomers of to-day.

The astronomy of position still occupies a very fundamental place in astronomy and there is a certain danger that its importance is being overshadowed by the new astronomy. The succeeding centuries may show that we must return to positional astronomy with more refined instruments and methods of observation, a more critical analysis of residual errors and a redetermination of the motions of the stars before we can make definite progress. I

think it will be of interest to you if I review the foundations upon which positional astronomy rests.

The fundamental instruments of observation are the transit-circle and the clock. The transit-circle consists of a central telescope, usually not more than nine inches in diameter, mounted on a transverse axis which is set east and west so that the telescope is free to swing in the meridian plane. Circles mounted on the tube enable one to measure the altitude, at which the telescope is set. In the focal plane of the object glass are two systems of spider threads, horizontal and vertical, usually one horizontal which can be moved by a micrometer screw and several—seven, thirteen or more—vertical ones placed symmetrically with respect to the centre. The observation consists of the following operations. A minute or so before a star is due to cross the meridian the telescope is set as nearly as possible at the correct altitude so that the star will cross near the centre of the field of view. It is then clamped. When the star is seen entering the field, the horizontal wire is moved near the star and the times of transit of the star across the wires to the one side of the centre noted. When the star is near the centre of the field of view it is bisected several times by the horizontal wire and the reading of the micrometer is noted. The times of transit of the star are then taken as the star crosses the wires on the other side of the centre. The circles which indicate the altitude at which the telescope was set are now read and the observation is complete. If in addition we note the time, or could note the time, when the vernal equinox crossed the meridian, we should have, from the times of transit, the right ascension of the star, and from the reading of the vertical circle and the reading of the horizontal wire, the declination of the star. The position of a star so determined is the apparent position only. The apparent position is affected by a multitude of circumstances, refraction, aberration, instrumental errors, etc. But leaving aside this mass of detail, it can at once be seen that the right ascension so obtained must depend on the accuracy with which the position of the vernal equinox is known.

The vernal equinox is not a point in the sky which can be directly observed. It is defined as that point on the celestial equator where the sun intersects it in passing from the southern to the

northern hemisphere. In order to determine its position, the clock time of transit of the sun is observed, day after day, throughout the year as well as the altitude at which it crosses. At the same time observations are made of the transit of stars. The position of the equinox, therefore, can be determined with reference to the stars transited, but only with reference to them. There is no fixed reference point in space. If this kind of observation were continued year after year, century after century, and more and more stars were included, there would be a continual increase in the accuracy with which the vernal equinox would be determined, both in regard to its position at any one time and in regard to its rate of motion, because it has been found to move. At the present time observation of this fundamental type is confined to a comparatively small list of brighter stars, the so-called fundamental stars, and the positions of the fainter stars are determined differentially from the fundamental ones. It follows, therefore, that at the present time the positions and rates of motion of the stars in the sky rests upon a selected list of stars. If this system has a rotation with reference to the fainter stars, it would react on the motion of the fainter stars and give them an apparent relative rotation in the opposite direction.

Such considerations as these are probably not important in determining the percentage error which exists in our proper motions of the more rapidly moving stars, but they assume an importance for those of small proper motion like the Cepheid variables. The remedy is to keep increasing the number of fundamental stars and from time to time redetermining the position and motion of the vernal equinox.

The determination of the declinations of the stars does not involve the difficulty of the determination of the vernal equinox, but there is another difficulty. Before the altitude at which a star crosses the meridian can be determined, a correction for refraction has to be introduced, a correction which it is impossible to evaluate with certainty. There is evidence of systematic error in the proper motion in declination. It would appear, however, that time will decrease the effect of this error because, being of a definite magnitude, we have only to wait until the displacement of the stars is

sufficiently large to render it an unimportant factor. It is of importance at present because the time of our interval, since the first accurate observations were made, is so short that the total displacement for the slow moving stars is small.

Great improvement has been made in the technique of observing the time of transits both in regard to the method of transit and in the clocks which record the time. The older methods of noting the transit consisted in the observer tapping an electric key as he observed the star image cross each wire, and this made an electric circuit complete so that the instant of transit was recorded on a revolving drum. The method suffered from the serious defect of personal equation. Later methods employed a small motor to shift a movable wire across the field. It is the duty of the observer to alter the rate so as to keep the star bisected, and, as the movable wire crosses the fixed wires, it automatically makes electric contact. It would seem that even the small personal element entering through the observer bisecting the star image might be superseded by some form of photographic registering device. The time is at hand when improvements in this part of the process should be made because the latest free pendulum clocks are of such a high standard that they will register the time more accurately than it can be determined from a single night's observing.

The transit-circle observations which are fundamental have been supplemented by the photographic plate. The image of the stars appear on the plate as points of light, and if there are a number of stars whose positions have been determined with the meridian-circle, the positions of the others can be obtained with extreme precision relative to these, but only relatively. The measures are extremely accurate when we are considering small periodic displacements such as introduced by parallax. Thus it is that the photographic method has proved far superior to all others in measuring the distances of the stars, and the parallaxes of upwards of four thousand stars have been determined by this method.

To summarize the present state of positional astronomy in a paragraph, we may say that four centuries of painstaking investigation and observation have established the law of gravitation, have yielded the fundamental positions of several thousand stars, the

accurate differential positions from these of 100,000 more and the reasonably accurate proper motions of 10,000 stars. Photographic measures have also added the distances of about four thousand of the nearer stars. The improvements in the methods and instrumental equipment have been so great that the number and accuracy of determined motions in the next equal interval of time will exceed many times those already determined.

I cannot pass over this branch of astronomy without mentioning an instrument recently devised for detecting large proper motions called the blink microscope or stereocomparator. It consists of a device whereby two plates of the same field of stars can be viewed, the one with one eye and the other plate with the other, and the two images are so superimposed that one gets the impression of one picture. It is found that those stars which have moved any considerable distance more than the others on the plate during the interval within which the plates were taken seem to stand out in relief so that their detection becomes very easy. When used in this way the instrument is known as a stereocomparator. It is also provided with a shutter so that either plate may be viewed separately at short intervals of time, and when used in this way any star which has altered its brightness seems to flicker so that variable stars are easily detected. When used in this way it is known as a blink-microscope and the plates are said to be blinked.

Physical astronomy began with the discovery of the telescope. It is the astronomy of the multitudes. Comparatively few people have the training or inclination to appreciate the painstaking attention to detail demanded by the problems of the astronomy of position. The wonders revealed by the telescope, however, appeal to everybody, and the great increase in popularity, after the improvement of the telescopes introduced by Herschel, gave an impulse to the subject which made the 19th century one of great activity.

Enthusiastic observers like Herschel worked the greater part of twenty-four hours a day, and every new discovery was the incentive to renewed activity, not only to the discoverer, but to hosts of others as well. The discovery of sunspots, the phenomena of Jupiter's satellites, the return of Halley's comet, the discovery

of Uranus, the discovery of variable stars together with the conditions which they implied, showed that much could be learned about the universe, not only from measures of position of the objects, but also from their appearance and variability.

Leaving aside the discoveries which were made with reference to the solar system, the rotation period of the sun, the variability in the number of spots, the phenomena of Saturn's rings and the satellite systems of the various planets, all of which attracted a great deal of attention and interest, we shall confine our attention largely to the development in our knowledge of the stars, so long regarded as a mystery never to be solved. Two phenomena could be observed with the telescope, the number of the stars, and their brightness.

Sir William Herschel was the first one to realize the importance of counting the stars. With the aid of the telescopes, which he himself constructed, he is said to have completely surveyed four times the heavens which he could see. In the course of this survey he discovered 2,500 nebulae, over 800 double stars and counted the stars in 3,400 fields. These labours were not directed toward the goal of merely collecting material, but made with a definite aim in view. Already the philosophy of Kant and the theories of Lambert had asserted that the stars formed one large cluster in the form of a flattened oval, and beyond this there were probably others. Herschel undertook to accumulate the data necessary to prove or disprove these ideas. His gauges led him definitely to the conclusion that the stars did not extend indefinitely in all directions. The sun was near the centre of a cluster several times as long as thick. He conceived the plane of this watch-shaped aggregation to be the plane of the milky way. Moreover, from the motion of a few stars, which had already been discovered, he was led to the conclusion that the sun was drifting through space, and he assigned a remarkably accurate direction for this motion. Herschel also observed double stars. He saw in them the crucial test of the Copernican theory. He conceived that two stars, which were close together in the sky, were in reality widely separated in space, and therefore by watching them he expected to see an annual shift due to the effect of parallax as the earth moved about the sun.

But in this he was mistaken. He showed later that the two stars in most doubles were actually close together in space and revolved about each other.

The conclusion of Herschel, that the sun was moving among the stars, was not immediately accepted. It showed, however, that the stars could be studied otherwise than as mere reference points in the study of the earth and planets. The discovery was all the more welcome because the law of gravitation seemed to have become so well established that there was danger, so men thought, of reaching a final solution with no more problems to conquer. Heretofore the only accurate star positions were those of Bradley in England. These had been made in an attempt to find a stellar parallax, an attempt which did not succeed. Bessel was the pioneer in the renewed interest in stellar positions and he finally determined the parallax of a star.

By 1837 Argelander, working with Bessel, had at his disposal the motions of 390 stars from which to deduce the solar motion. The results agreed very closely with those of Herschel determined from eleven stars only. The reality of the sun's motion through space was definitely established. But under what attraction was it moving? Was there a centre to the universe? These were questions which the astronomers of the 19th century could not hope to answer because they did not have sufficient data. At every step the astronomer finds that he needs facts and still more facts before he can make progress. We have been accumulating data on this problem down to the present. Time does not permit me to trace in detail the various methods that have been used, nor to allot credit to the many astronomers who have helped to secure the observations. One important discovery stands out from the others. In 1910, Professor Kapteyn announced that, in addition to the solar motion, the stars were moving in two streams. There seemed to be a direction in space along which the stars moved more rapidly than in directions at right angles. We shall see later how this discovery fits into our scheme of things.

Let us now turn to a review of the progress which has been made in another field, that of spectroscopy. The spectroscope, known since the time of Newton, became an instrument of astro-

nomical research with the discoveries of Kirchhoff, who interpreted the meaning of the various kinds of spectra. The spectrum of a source is simply the light spread out by refraction or diffraction into a coloured band passing from deep red through crimson, orange, yellow, green, blue and violet. The reason for this is that the various colours of light are due to the wave-length and light of different wave-lengths are refracted differently by a prism. The shortest waves, which are the violet, are deviated the farthest from their original path and the red, or longest waves, the least. The visible spectrum extends at both ends into regions which the eye does not appreciate as light but which can be detected by the photographic plate.

The light coming from all sources when heated is not the same. An incandescent solid or liquid or a gas under great pressure gives what is called a continuous spectrum, that is, the light present is of all colours. When viewed through the spectroscope the colours of the band of light merge continuously without any breaks from red at one end to violet at the other. Gases at low pressure, on the other hand, emit colours of only a few tints so that the spectrum is discontinuous and consists of a few bands or lines. Moreover, it is found that the particular colours which are present are definitely characteristic of the particular gas which is used as a source of light. It is further found, that if the light from a source giving a continuous spectrum passes through a cooler gas on its way to the observer, the coloured band of light is interrupted by dark lines in precisely the places where the cooler gases would show bright lines when emitting its own spectrum. The spectrum is said to be reversed.

The spectrum of the sun and stars consists of continuous spectra crossed by dark lines. The particular dark lines which are present tell us the various elements which exist in the atmospheres of these bodies. Thus at once a whole realm of investigation is opened up, which in the early part of the 19th century was considered beyond the possibilities of investigation. For a long time the origin of the continuous spectrum from the stars was in doubt, whether it was due to an incandescent solid, liquid or gas. We now believe that is it due to incandescent gases. The spectroscope showed that many

of the nebulae were entirely gaseous, while others again gave continuous spectra as if composed of myriads of stars too far away and too faint to be photographed individually by the telescope. I have already referred to the triumph of the 100-inch telescope in actually verifying this interpretation in the case of the Andromeda nebula.

It is not my intention to enter into the details of the various spectra which the stars show, nor their interpretation in terms of the conditions which exist in the stars. I am attempting, rather, to trace the ideas which have gradually accumulated as to the arrangement and disposition of all the stars which form our universe, and to this larger problem the question of the conditions and development of the individual star is only incidental. It is a problem that is particularly suited to mathematical analysis. It would seem that, given a mass of gas with any arbitrary initial conditions, one should be able to trace its life history from purely mathematical and physical ideas. This constitutes a special branch of investigation known as stellar dynamics, which has been pursued in recent years by Milne, Eddington, Jeans and others with great success.

The spectroscope enables us to tell another thing about the stars that I wish to emphasize more than the determination of the constitution. It was discovered that the position of the absorption lines in the spectrum was affected by the velocity of the observer or the velocity of the source. If these are such that the two are approaching one another, then the lines in the spectrum are shifted slightly to the violet, and if shifted to the red, it means that the observer and source are receding from each other. It is possible, therefore, by measuring the displacement of the lines, to measure the rate in km. per sec. at which any star is approaching or receding from the earth. We have already dwelt at some length on the information afforded by the proper motion of the stars. The latter is an angular rate of motion of the stars across the line of sight and cannot be converted into actual motion in km. until we know the distances. The motions, toward or away from us, add greatly to our knowledge. Proper motions had determined the direction of the sun's motion, but could not give the speed of this velocity. Velocities in the line of sight supplied this information. Taken in conjunction

with the proper motions, they will determine the mean distances of groups of stars which are too small to be directly measured. The first accurate velocities were obtained about 1895, and by 1916 there were at hand over 1,600 stars whose velocities in the line of sight had been determined. All investigations, based on the radial velocities in combination with the proper motions, gave results which showed that Kapteyn's general scheme of a flattened watch-like structure was the correct picture, with the sun not far from the centre.

It was realized, however, that all the stars treated were those in our immediate neighbourhood. Direct photographs had depicted, in great detail, other objects, namely, the spiral nebula and clusters, which were obviously much more remote. No one had been able to determine any movement for these objects. The appearance of the milky way and the oval-like structure of the stars around us strongly suggested that our system might be a spiral nebula. The appearance of the latter suggested that they were in rotation. Several things had to be settled before such an hypothesis could be accepted. The distance of the spiral nebula and clusters must be determined, and the extent of these objects. Also, we must be able to say something about their rotation, and the rotation of our own groups of stars.

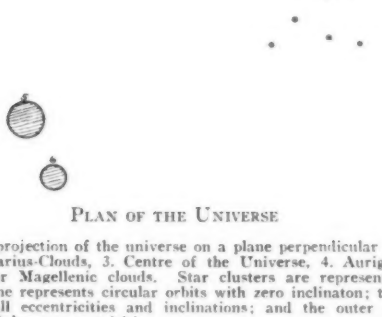
Help came from a very unexpected quarter. For a very long time astronomers had been studying the variability in the light of many of the stars. The researches were undertaken with the idea of throwing light on the inner mechanism of a star. The results obtained show how knowledge in one department of a science may prove of the utmost value in another. Miss Leavitt of the Harvard College Observatory, working with the variables in one of the Magellanic clouds, found that there was a direct relation between the period of light variation and the apparent brightness. Since all the objects were at the same, or nearly the same, distance, her discovery was equivalent to a relation between the period of light variation and the real light-giving powers of the stars in question. These variables have been called the Cepheid variables. Miss Leavitt's discovery enabled one to determine the relative distances of objects in which variables of this nature had been discovered;

and if, by any other means, the distance of any of these objects could be determined absolutely the distances would be fixed for all. The objects used for this purpose are the local Cepheid variables. Variable stars of the Cepheid type exist in the stars of our own group, and attempts have been made to obtain their mean distance, both from directly measured parallaxes and from their proper motions combined with the radial velocities. It is not yet certain that the mean value so obtained is at all accurate. The parallaxes have been determined from comparatively few, so that the mean is not very trustworthy. The proper motions are so small that systematic error may cause large errors in this method. There is another factor, also, which makes the result uncertain. Their mean distances, calculated from their proper motions, rest on the assumption that there is no absorption of light on its journey to the observer. Evidence is accumulating that this assumption is not justified. It is one of the problems that call for urgent investigation. The distances of the spiral nebulae and clusters are certainly enormous, of the order of a million light-years, but the figures may be considerably altered in the future. We can assert that we know the correct order of distance only.

There is, however, another line of attack which is proceeding along lines somewhat similar to the trend that took place in the establishment of the law of gravitation. We have seen that at first the Copernican doctrine was a theory only. Then followed the early observations of Tycho Brahe, and their analysis by Kepler. The complete explanation was found in the law of gravitation. All subsequent measures have shown that they agree with this law to a very high degree of accuracy. Parallel with this, we now have the hypothesis that our whole cluster of stars is similar to a spiral nebula. We are in the process of making the measures of motions and velocity in the line of sight which may be compared with the early observations of Tycho Brahe. These have been studied by many astronomers as Kepler studied the planetary motions, and many facts discovered, not as simple it is true, as Kepler's laws, but yet showing that laws exist. We have already referred to Kapteyn's discovery of the star streams. Researches by Strömberg and others have shown that different classes of stars

exhibit this phenomenon in different degrees and the work of Oort and others has shown that the stars known as B-type indicate a general rotation about a distant centre. Now the question is whether statistically all these facts can be explained on the hypothesis that our system of stars is indeed a spiral nebula, and that the individual stars revolve about a more or less condensed centre exactly as the planets revolve about the sun?

In a very illuminating paper in the "Ergebnisse der Exakten Naturwissenschaften", Bottlinger treats this question and finds, that very good agreement with the observed facts can be obtained. The conception of the universe of stars, which he obtains, is illustrated



PLAN OF THE UNIVERSE

The diagram is a projection of the universe on a plane perpendicular to the Milky Way. 1. The Sun, 2. Sagittarius-Clouds, 3. Centre of the Universe, 4. Auriga-clouds, 5 and 6. The smaller and larger Magellenic clouds. Star clusters are represented by small open circles. The central line represents circular orbits with zero inclinaton; the dotted ellipse, a second class with small eccentricities and inclinations; and the outer ellipse, those with higher inclinations and large eccentricities.

in the diagram below. At 3 we have the gravitational centre of the stars at a distance of about 20,000 light-years from the sun. Moving about this in various orbits are different classes of objects, some with orbits nearly circular and almost in the plane of the milky way. Others slightly eccentric and more inclined, and still others highly eccentric and their orbits considerably inclined to the plane of the milky way. The star-clusters and the Magellanic clouds are in the system, the latter far remote. Still farther away but not shown in the diagram, we should have the spiral nebulae as independent universes. The statistical relations we observe in regard to

motions of the stars around us, is a consequence of these various orbits.

In conclusion, therefore, I might say that we have arrived at a very definite picture of the universe. It is not expected that it will prove correct in all its details, that is not important. It serves as a starting point of investigation. The data needed are more proper motions and more velocities. It will be the aim of the new observatory to help secure these. An institution that possesses a large telescope is indeed in a very fortunate position. With small telescopes the programme of observation has to be very carefully selected, for otherwise the observer will find himself checking over results already obtained without adding greatly to knowledge. The large instrument enables one to attack new fields. Its usefulness depends upon the industry of the observers. Results cannot fail to follow if the observations are made. The new telescope, when it is finally installed, will be used on every available clear night from sunset to sunrise, and I am sure we may look forward to the observatory making contributions to our knowledge which will help to solve this most fundamental problem of all in astronomy, the structure of the universe.

ANNUAL GENERAL MEETING OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The annual meeting of the Society, held on Tuesday, January 10, 1933, in the McLennan Laboratory, (Physics Building), of the University of Toronto, was called to order at 8.15 p.m. by the president, Dr. R. K. Young.

The Minutes of the Annual Meeting of January 19, 1932, were adopted.

Miss E. M. Budd, and Mr. F. L. Troyer were appointed scrutineers by the chairman, and later reported that the voting was almost unanimously in favour of the names printed on the ballot. The Chairman then declared that the following were duly elected officers of the Society for 1933:—

Honorary President—Mgr. C. P. Choquette, M.A., Lic.Scs., Montreal.
President—R. K. Young, B.A., Ph.D., Toronto.
First Vice-President—Lachlan Gilchrist, M.A., Ph.D., Toronto.
Second Vice-President—R. E. DeLury, M.A., Ph.D., Ottawa.
General Secretary—R. A. Gray, B.A., 198 College St., Toronto.
General Treasurer—J. H. Horning, M.A., Toronto.
Recorder—E. J. A. Kennedy, Toronto.
Librarian—R. A. Gray, B.A., Toronto.
Curator—R. S. Duncan, Toronto.
Council—D. S. Ainslie, M.A., Ph.D.; F. Napier Denison, Victoria, B.C.; Miss A. Vibert Douglas, Ph.D., Montreal; Wm. Findlay, Ph.D., Hamilton, Ont.; E. A. Hodgson, Ph.D., Ottawa; A. R. Hassard, K.C., Toronto; J. A. Pearce, Ph.D., Victoria; J. Patterson, M.A., Toronto; John Satterly, M.A., D.Sc., Toronto; L. A. H. Warren, M.A., Ph.D., Winnipeg.

The Reports of the General Secretary and Librarian were presented and accepted. The Reports of the secretaries and treasurers of the various Centres were received and approved.

The Financial Statement was presented by Mr. J. H. Horning, the General Treasurer. Moved by Prof. L. Gilchrist, seconded by Mr. J. R. Collins, that this report, as audited by Mr. A. R. Hassard, be received. Carried.

The thanks of the Society were tendered to the auditors. Mr. A. R. Hassard and Mr. J. E. Maybee were appointed auditors for the coming year.

There was a discussion on the need for new quarters for the library, and on the desirability of an inventory of the assets of the Society:—the library, apparatus, and publications on hand.

The Meeting adjourned.

E. J. A. KENNEDY,
Recorder.

LIBRARIAN'S REPORT

In the year just completed the usual progress may be noted. The great need is a more suitable and more generally accessible room in which to house the library. There are in it many valuable reports of scientific societies that are seldom or never consulted and which might be of great value if available to a class of reader of a more advanced type than the general calibre of our members, space taken up by these reports might be used for works of a more popular character.

We again call the attention of the members to the library with the hope that a more generous use may be made of it in the coming year.

The number of periodicals received during 1932:

From Canada and the Empire	176
From the United States	181
From other countries	147
Total	504

The number of books borrowed by members was 104, and volumes of periodicals were on several occasions loaned to other libraries. No binding was done in the past year owing to shortage of funds.

R. A. GRAY,
Librarian.

GENERAL SECRETARY'S REPORT

During the year 1932 two new centres have been established, one at Vancouver, B.C., and the other at Edmonton. Requests for the formation of these centres were brought to the attention of the Council and they were granted with pleasure. Both centres have begun under favourable auspices and reports of their activities are given elsewhere.

That the JOURNAL continues to be much sought for in various places all over the world is conclusively shown in the number of requests for exchange that are made. Many of these have to be refused on account of lack of funds, but wherever it is thought that a publication can be of service to our Society every effort is made to arrange an exchange. A valuable General Index to volumes I-XXV and previous publications of the Society, compiled by W. E. Harper of the Dominion Astrophysical Observatory, was printed early in the year, and is on sale at $1.05. The sales of the *Observer's Handbook* increased in the past year; it was supplied for class use to several universities and schools and to various non-members at twenty-five cents a copy.

The most memorable event of the year in the astronomical world was the solar eclipse of August 31st. A large number of our members visited the Province of Quebec, and reports of these expeditions have been published.

R. A. GRAY,
General Secretary.

MEMBERSHIP OF THE SOCIETY

The membership of the Society on Dec. 31, 1932, as shown by the reports of the different Centres, was as follows:—

	1931	1932
Toronto	174	175
Ottawa	64	61
Victoria	118	116
Montreal	115	110
Winnipeg	47	55
London	70	71
Hamilton	40	66
Vancouver		71
Edmonton		48
Members at large	104	104
Total Membership	733	877
Subscribers to JOURNAL	64	68

E. M. BUDD,
Assistant Secretary.

Reports of the Secretaries of Centres

Toronto Centre

The membership at the beginning of 1932 was 174. New members elected, 18; resignations and removals, 16; death, 1, leaving the present membership 175.

We regret to report the death of Miss M. E. Watt, a member of long standing. She held the position of treasurer until forced to resign at the commencement of her last illness.

In connection with our membership, it is a great pity that in a large city like Toronto our numbers are not greater. A more determined effort on our part should be put forth to attract new members. Such an entrancing subject as the study of the stars and the Universe should be a cure for depressed spirits, and an antidote for the strain of modern economic conditions.

The meetings of the Toronto Centre were as follows:—

Jan. 12—New and Old Methods of Determining the Earth's Magnetic Field, W. E. W. Jackson,
Jan. 26—At-Home of the General Society. Retiring President's Address.
Feb. 9—Newton and Laplace, Prof. Chapelon, D.Sc.
Feb. 23—Measuring Stellar Distances, J. H. Horning, M.A.
Mar. 8—History and Development of the Calendar, W. S. Armstrong, B.A.
Mar. 22—Electrons, Protons, X-Rays, and Cosmic Rays, Prof. L. Gilchrist.
Apr. 12—An Evening with Galileo, David J. Howell.
Apr. 28—Expeditions to Quebec to Observe the Total Eclipse of the Sun, August 31, 1932.
May 10—Proposed Methods of Observing the Total Solar Eclipse.
Oct. 18—Reports of Members of Solar Eclipse Expeditions. Address by Chairman, Mr. J. R. Collins.
Nov. 1—The Mythology of the Stars, Major E. H. Anundson, London, Ont.
Nov. 15—The Spectroscope, Prof. H. J. C. Ireton.
Nov. 29—Under the Southern Cross, Mr. Henry Westoby.
Dec. 13—Recent Developments in Weather Forecasting, Andrew Thomson, M.A. Annual Meeting for the election of officers and receiving of reports.

It is pleasing to report that a large number of the Toronto members were fortunate enough to view the total solar eclipse at Louiseville, Quebec. The Society's eclipse expedition was in charge

of Mr. J. R. Collins, the party consisted of over 50 people from different parts of Ontario. London Centre sent a large contingent under Dr. Kingston. It was an unforgettable experience. The R.A.S.C. may be congratulated as one of the very few Solar Eclipse Expeditions to be favoured with an uninterrupted view of the glorious spectacle.

The following were elected as officers of Toronto Centre for the year 1933:—

Honorary President—Sir Frederic Stupart.
Chairman—R. A. Gray, B.A.
Vice-Chairman—A. R. Hassard, K.C.
Secretary—E. J. A. Kennedy.
Treasurer—Dr. Wm. Wunder. (Later, J. Edward Maybee).
Recorder—S. C. Brown. (Later, Gordon Hepburn).
Curator—Robt. S. Duncan.
Assistant Curator—Fred. L. Troyer.

STANDING COMMITTEES

Finance—Dr. W. M. Wunder, H. W. Barker, Dr. J. B. Fraser.
Programme—R. A. Gray, B.A.; J. R. Collins, Dr. R. K. Young, Dr. L. Gilchrist, E. J. A. Kennedy.
Membership—Dr. R. K. Young, J. H. Horning, M.A.; Miss E. M. Budd.
Building—H. L. Rogers, Dr. C. A. Chant, A. R. Hassard, A. F. Miller.

E. J. A. KENNEDY,
Secretary.

OTTAWA CENTRE

During the year 1932, 3 public lectures were held by the Ottawa Centre in the lecture hall of the Victoria Memorial Museum, and 5 technical talks were given at the Dominion Observatory.

The public lectures were as follows:—

Jan. 15—The Nebulae, Prof. A. H. S. Gillson, M.A. (Cantab).
Feb. 19—Up-To-Date Puzzles (Theories) in Physical Science, Dr. R. W. Boyle, F.R.S.C.
May 28—The Total Solar Eclipse of Aug. 31, Dr. R. K. Young and Dr. R. E. DeLury.

The technical talks were:—

Jan. 29—The Theory of Errors, R. Meldrum Stewart, M.A.
Mar. 4—Electron Emission in Radio Tubes, J. P. Henderson, M.A.
Apr. 15—The Theory and Operation of the Eotvos Torsion Balance, A. H. Miller, M.A. (Oxon).

Apr. 29—Decoding Seismograms, W. W. Doxsee, M.A.
Nov. 25—Seismology and Earth Structure Theory, Dr. E. A. Hodgson.

In addition to these, one regular council meeting and 7 emergency meetings were held at the Dominion Observatory.

The membership now stands at 61. One member, Mr. Cawthray, passed away during the year, 4 members resigned, 6 were dropped for non-payment of fees, and 10 new members joined the society.

Information regarding the eclipse of last August was sent to all members, and in addition, each member was given a copy of the booklet "Eclipse of the Sun", by A. Norman Shaw and A. Vibert Douglas.

As in other years, the various issues of the Observatory's Saturday evening programme were sent to the members.

At the Annual Meeting of the Ottawa Centre, R.A.S.C., held on Tuesday, December 20th, the following officers were elected for the year 1933:—

Honorary President—J. S. Lane, B.A.
President—R. Glenn Madill, B.A.
Vice-President—A. H. Miller, M.A.
Secretary—Miriam S. Burland, B.A.
Treasurer—A. W. Grant, B.A.
Council—N. A. Irwin, B.A.; J. P. Henderson, M.A.; J. McLeish, B.A.; and past presidents, R. Meldrum Stewart, M.A.; R. E. DeLury, Ph.D.; R. J. McDiarmid, Ph.D.; C. R. Coutlee, C.E.; C. C. Smith, B.A.

MIRIAM S. BURLAND,
Secretary.

MONTREAL CENTRE

During the year 1931-32 ninety-six members remitted their fees and twelve failed to do so. The mailing list contained 110 names, there being two Life Members. Eighteen names were removed during the year, through resignations and failure to remit fees. Sixteen new members were welcomed into the Society.

The six meetings held during the year were well attended and are listed below:—

Oct. 22, 1931—Theories of Cosmology, Ancient and Modern, Dr. A. V. Douglas.

Nov. 20, 1931—The Nature of the Universe and the Expansion of Space, Dr. W. de Sitter (Leiden).

Mar. 3, 1932—The Mechanics of the Universe, Professor A. H. S. Gillson.

Mar. 31, 1932—Time—Its Measurement and Determination, Prof. E. W. Brown (Yale).

Apr. 21, 1932—Total Solar Eclipse, (McGill University, Lyceum Lecture), Dr. A. V. Douglas.

May 25, 1932—Science and Philosophy, Dr. A. N. Whitehead, F.R.S., (Harvard).

A. VIBERT DOUGLAS,
Secretary.

LONDON CENTRE

During the year 1932, the London Centre held nine regular meetings, with a total attendance of 523. A summary of these meetings follows:—

Jan. 8—Attendance 47. Lecture, Newer Developments in Calendar Reform, Major E. H. Anundson.

Feb. 12—Attendance 40. Lecture, How to Measure the Distances of Stars, Mr. R. A. Gray, (Toronto).

Mar. 11—Attendance 48. Dr. H. S. Wismer demonstrated a sextant, explaining the construction and use of this instrument. Lecture, Relativity and the Astronomer, Dr. R. C. Dearle.

Apr. 8—Attendance 35. Lecture, The Spectrum, Mr. F. H. Coates. Demonstration of X-rays, at the office of Dr. H. S. Wismer.

May 13—Attendance 165 (open to the public). Lecture, Solar Eclipses, Dr. H. R. Kingston.

June 11—Attendance 44. Annual picnic at the farm of Mr. Thos. Wonnacott, Delaware.

Oct. 14—Attendance 67. Lecture, The Mythology of the Stars, Major E. H. Anundson. A report on the variations in the intensity of light during the solar eclipse of August 31, Mr. F. H. Coates.

Nov. 11—Attendance 33. Lectures on the Telescope, Mr. F. H. Coates, Mr. D. M. Henningar, Mr. George Gunn, and Rev. W. G. Colgrove. (Refracting and reflecting telescopes made by these members were exhibited.)

Dec. 9—(Annual Meeting). Attendance 44. Moving pictures of the Solar Eclipse of August 31, 1932, Mr. W. J. Milne (Hamilton). Demonstration, How to Measure the Temperatures of Stars, Mr. F. H. Coates.

Three Executive Committee meetings were held, on January 6, August 15, and October 25. The meeting of August 15 was a joint

meeting with the Eclipse Committee of the London Centre. At this meeting it was decided to abandon the original decision of the Eclipse Committee to purchase a self-recording photometer; the reasons for this decision were (1) that a Toronto manufacturing concern had offered to loan Mr. Coates an instrument which was much superior to the intended purchase; (2) that Mr. Coates had offered to the London Centre a photometer which he had constructed but which was not self-recording. The two committees requested Mr. Coates to take both instruments to Louiseville, Quebec, for the eclipse of August 31.

The year 1932 was marked by an interchange of speakers between the Toronto and London Centres—Mr. R. A. Gray (Toronto) lecturing to the members of the London Centre on February 12, and Major E. H. Anundson (London) lecturing before the Toronto Centre on November 1. Constellation studies were conducted at the regular meetings throughout the year, under the direction of Mr. T. C. Benson and Dr. H. R. Kingston. Thirty members of the London Centre journeyed to Quebec at the end of August and most of these were fortunate in obtaining a clear view of the eclipse, at Louiseville.

The membership for the year 1932 was 71, an increase of one over that of last year.

Officers for 1933:

Honorary President—Dr. H. R. Kingston.
President—Mr. George Gunn.
Vice-President—Major E. H. Anundson.
Secretary-Treasurer—Miss N. Morris.
Council—Miss A. Callard, Mrs. W. P. Burns, Mr. S. J. Versteeg, Dr. H. S. Wismer, Mr. D. M. Hennigar.

G. R. MAGEE,
Secretary-Treasurer.

WINNIPEG CENTRE

During the past year, the Society held eight regular meetings in Theatre "A", University of Manitoba. All of these meetings were open to the public and were well attended. Executive meetings were held on two occasions, 12th November and 14th December.

It is with regret that we record the death of two members—Mr. M. McFadyen, 1196 Grosvenor Ave., and Mr. F. H. Martin, 240 Waverley Street.

Eight new members were elected during the year and within the past month, seven were nominated for election next year. Five resignations were received. The membership is 55 at present and is larger than it has been for some time.

On the 1st August the Society held a dinner at the Royal Alexandra Hotel, at which members of the Royal Astronomical Society, members of the British Astronomical Association, members of the Astronomical Society in France, in Belgium, in Italy and in Switzerland were the guests of honour. The speakers on this occasion were Dr. Knox-Shaw, President of the Royal Astronomical Society; Dr. F. W. Aston of Trinity College, Cambridge; Dr. Duncanson, President of the British Astronomical Association; Mr. Goodacre, Past President of the Royal Astronomical Society and Dr. N. J. Maclean, President of the Winnipeg Centre.

On the 20th August, the Astronomer-Royal, Sir Frank Dyson, gave an illustrated address on the "Eclipse of the Sun" in Theatre "A". This address was given under the auspices of the National Council of Education who had made arrangements with the Astronomer-Royal for a series of lectures to be given at various cities in Canada, from coast to coast. The members of the Winnipeg Centre were invited to co-operate and did so with much pleasure.

On 10th September the members of the Winnipeg Centre had the pleasure of renewing acquaintances with Dr. and Mrs. J. S. Plaskett, of Victoria, when Mrs. Neil John Maclean entertained in their honour.

Observation meetings held under the leadership of Mr. A. W. Megget and Mr. D. R. P. Coats were exceptionally well attended and the enthusiasm displayed on these occasions bore testimony to the interest taken in this phase of the Study of Astronomy.

The subjects of papers presented during the year were as follows:—

Jan. 13—The Limitations of Life on the Planets, a further report on Meteorites, Professor V. W. Jackson, M.A.

Feb. 10—Weather, Mr. D. C. Archibald, M.A., M.Sc.

Mar. 9—Our Moving Observatory, Right Rev. T. W. Morton, B.Sc.

Mar. 23—Eclipses of the Sun, Dr. L. A. H. Warren, M.A., F.R.A.S.; Myths of the Constellations, Mrs. H. M. Sweet, B.A.

Apr. 13—Members' Night. Famous Cosmologies, Mr. A. V. Pigott; Astronomical Features of the Pyramid, Mr. Howard Nicholls; Nature of Time, Mr. R. McCalman; The Earth Moves, Mr. A. W. Megget.

Oct. 12—Short addresses on personal observations of the Eclipse of the Sun by Mr. D. R. P. Coats, Professor V. W. Jackson and Dr. L. A. H. Warren who had gone east to be near the centre of the path of totality on the 31st August.

Nov. 9—The Expanding Universe, Professor Frank Allen, M.A., Ph.D., F.R.S.C.

Dec. 14—Sir Wm. Herschel, Dr. L. A. H. Warren, M.A., F.R.A.S.

The Officers for 1933 are as follows:—

Honorary President—Dr. J. S. Plaskett, F.R.S.

President—Mr. A. W. Megget.

First Vice-President—Mr. D. R. P. Coats.

Second Vice-President—Professor V. W. Jackson.

Treasurer—Mr. J. H. Kolb.

Secretary—Mrs. J. Norris.

Assistant Secretary—Mrs. J. C. Howey.

Council—Dr. Neil John Maclean, Mr. C. E. Bastin, Mr. L. T. S. Norris-Elye, Mr. A. V. Pigott, Mr. F. Pugh, Mrs. H. M. Sweet, Mrs. E. L. Taylor, Dr. L. A. H. Warren.

Auditors—Mr. James Houston, Mrs. E. L. Taylor.

S. C. Norris,
Secretary.

Victoria Centre

Membership.

Membership, Jan. 1, 1932		118
Memberships lapsed	9	
Resignations	13	
Transfers to other centres	19	
Deaths	2	
Thus we lost during the year a total of		43
		75

This compares with losses of 9 in each of the years 1930 and 1931.

The large number of transfers was caused by our Vancouver members transferring to the newly formed Vancouver Centre.

Members elected during 1932	41
Membership at end of 1932	116

Of the present membership 40 are out-of-town members, 8 are junior members, elected under the resolution unanimously passed at the Regular meeting on April 22, 1932.

Included in the 116 members are two Life and one Honorary Member.

MEETINGS.

Nine Regular Meetings were held, programmes of these meetings being printed and mailed to all members. Attendance at these Regular Meetings averaged slightly over 60 persons.

In addition to the Regular Meetings the Council instituted a Summer Study Course of 10 weekly meetings during which lectures were given on the fundamental doctrines of astronomy and opportunity afforded for observational experience and constellation study. Attendance at the Study Course greatly exceeded expectations, the average being 28.2. Of those enrolled, 20 attended eight or more meetings. It is hoped that arrangements can be made for continuing these meetings during the coming year. The Society's thanks are due to the Secretary of the School Board, Mr. W. F. C. Pope, for kindly lending chairs for these meetings free of cost to the Society.

There were 9 meetings of the Council during the year.

A delightful opportunity was afforded Victoria Centre to meet astronomers of other lands by the visit of members of the International Astronomical Union in August. Report of this visit appeared in the JOURNAL for October, 1932.

FINANCES.

The Secretary is pleased to be able to report that members have responded splendidly in paying up their dues. There are no delinquents for previous years and for 1932 outstanding dues are only $4.00. Five members have paid their dues for 1933.

Among the many ways by which members can help the Society, the Secretary would mention two, both very practical:

1. Paying their dues promptly, thereby relieving the Council of anxiety regarding the means of payment of current bills, and making an appreciable saving in postage expense.

2. Bringing in more members. Were each member to bring in one member more, the Centre would be in a much better position to carry on its work.

While the year closes with a small cash balance, it must be stated that this condition is largely the result of payments of back dues, advance payments of dues for 1933, and of the large number of new members received during the year.

Financial condition of the Centre is not satisfactory. That this is not due simply to present economic conditions, inspection of the Treasurers' Reports through the years shows. In spite of the most rigid economy, the Centre has never more than barely made both ends meet.

Its activities consequently are reduced to the narrowest limits and many ways of increased usefulness to its local members especially and to the public generally are necessarily indefinitely postponed.

It is to be hoped that some means may be found whereby a fund can be established from the proceeds of which this condition can be remedied.

In conclusion the Secretary-Treasurer desires to express his gratitude to the members of the Council for their direction, advice and guidance during the year and to wish all members a Happy Christmas and a Prosperous New Year.

OFFICERS FOR 1933

Honorary President—James Duff, M.A., Sidney, B.C.
President—Philip H. Hughes, Mus.Bac., Victoria, B.C.
First Vice-President—N. C. Stewart, C.E., B.C.L.S., Victoria, B.C.
Second Vice-President—Charles Hartley, M.A., Victoria, B.C.
Librarian—W. T. Bridge, 1035 Mears St., Victoria, B.C.
Secretary-Treasurer — H. Boyd Brydon, M.E., 2390 Oak Bay Ave., Victoria, B.C.

Council—G. Browne-Cave, Victoria, B.C.; W. Burton, Victoria, B.C.; T. J. Greenway, F.I.C., Victoria, B.C.; F. S. Hogg, Ph.D., Victoria, B.C.; W. F. Holdridge, Victoria, B.C.; H. E. Moore, M.A., Victoria, B.C.

NOTE: Past Presidents are ex-officio members of the Council.

H. Boyd Brydon,
Secretary-Treasurer.

Hamilton Centre

During the year 1932 Hamilton Centre held eight regular meetings, all of which were open to the public and were well attended.

Jan. 12—Our Sun, Dr. D. B. Marsh.
Feb. 9—The Motions of the Moon, Prof. Wm. Findlay, M.A., Ph.D.
Mar. 8—Einstein's Theory of Relativity, Prof. Wm. Findlay.
Apr. 13—The Total Eclipse of the Sun next August, Dr. H. R. Kingston.
May 10—The Total Eclipse of the Sun in 1925, Dr. D. B. Marsh.
June 9—Field night held at the residence of W. T. Goddard.
Nov. 8—A report on the recent eclipse of the sun given by members of the party from Hamilton Centre.
Dec. 13—The Motions of the Earth, Mr. J. S. Taylor.

In addition a public meeting was held on Oct. 6 at which an admittance was charged, and the proceeds credited to the Centre. The programme was given by members of the eclipse party, and Dr. D. B. Marsh was the speaker for the evening.

The Hamilton Centre has at present 66 members. During the year 12 new members were elected, while two moved away, one resigned and one died.

Some of the members of the Hamilton Centre planned a party to photograph the eclipse of the sun on August 31, the funds were raised by public subscription. The party's efforts were crowned with complete success, many fine photographs being taken from which slides were made, and shown at a regular meeting of the Centre.

The list of officers elected for 1933 at the Hamilton Centre is as follows:—

Honorary President—Rev. D. B. Marsh, D.Sc.
President—W. S. Mallory, M.A.

Vice-Presidents—W. T. Goddard, B.Sc.; T. H. Wingham, B.A.Sc.; Prof. Wm. Findlay, Ph.D.
Secretary—J. A. Little, B.A., 9 South Oval.
Treasurer—G. E. Campbell.
Curator—W. T. Wingham.
Council—Dr. Gordon M. Jackson, W. G. Milne, E.E.; S. C. Scammell, Mrs. S. C. Scammell, Prof. A. E. Johns, M.A.; J. A. Marsh, Rev. John Samuel, T. H. Waring.

Vancouver Centre

Since the organization of the Vancouver Centre in November, 1931, eleven regular meetings have been held at the University of British Columbia.

Nov. 10, 1931—The Making of Worlds, Dean D. Buchanan.
Dec. 8, 1931—Telescopes and Telescope Makers, Mr. H. C. B. Forsyth; Exhibition of Telescopes, H. C. B. Forsyth, M. A. McGrathe, J. Teasdale, J. A. Mackenzie, J. L. Bennett, W. Stothard.
Jan. 12, 1932—The Nature of a Star, Dr. Grayson Smith.
Feb. 9, 1932—Rotation of the Galaxy, Dr. J. A. Pearce.
Mar. 8, 1932—Our Knowledge of Light, Dr. G. M. Shrum.
Apr. 12, 1932—The Picturesque in Astronomy, Mr. T. J. McGill; The Sextant and its Uses, Mr. C. A. Macdonald.
Aug. 9, 1932—The British Eclipse Expeditions; the Work of the Radcliffe Observatory, Dr. Knox-Shaw, President, Royal Astronomical Society (London).
Sept. 6, 1932—Outside observations with members' telescopes; the Moon and the Solar System, Dean D. Buchanan.
Oct. 18, 1932—Einstein and Astronomy, Mr. F. J. Brand, B.A., B.Sc. (Oxon.)
Nov. 8, 1932—Light and Colour, Dr. J. G. Davidson.
Dec. 13, 1932—Symposium—the Solar System, The Earth, Prof. A. Lighthall; The Inner Planets, Mr. J. L. Bennett; The Outer Planets, Mr. A. Outram.

On August 17 a special meeting was held at which Sir Frank Dyson, K.B.E., LL.D., F.R.S., Astronomer Royal of Great Britain, gave an illustrated address on "The Contribution of the Royal Observatory to Navigation and Astronomy".

In addition to these there were four meetings of the Council.

The membership now stands at 71.

Officers for 1933:—

Honorary President—Dean D. Buchanan.
President—J. Teasdale.

First Vice-President—H. C. B. Forsyth.
Second Vice-President—F. R. Williams.
Treasurer—J. L. Bennett.
Secretary—J. R. Pollock.
Recorder—William Ure, M.A.Sc., Ph.D.
Council—Mrs. C. M. Robson, Stanley Burke, N. H. Hawkins, J. A. Mackenzie, C. A. Macdonald, M. A. McGrathe, A. Outram, H. A. Pitman, S. A. Richmond, Rev. C. H. Shortt, G. M. Shrum, M.A., Ph.D., (retiring President).

WILLIAM URE,
Recorder,
for the Secretary.

EDMONTON CENTRE

During the year 1932, the Edmonton Centre held nine regular meetings and one special meeting.

Jan. 14—Organization meeting, with Dr. J. W. Campbell presiding and 17 others present.

Feb. 3—Second organization meeting, and signing of a petition asking permission to start an Edmonton Centre; Jupiter, Dr. J. W. Campbell.

Mar. 1—Algol, Mr. Kenneth E. McShane; Adoption of the constitution and by-laws.

Mar. 15—The Moon, Mr. Hugh H. Beach.

Apr. 12—Ten minute talk, The Sky for April, Dr. J. W. Campbell; Meteors, Dr. E. H. Gowan.

May 10—Ten minute talk, Mars and Saturn, Mr. Harold Poole; Eclipses, Mr. Ken. F. Alexander.

Oct. 11—Ten minute talk, Halley's Comet, Mr. Wilfred E. Rose; Report on Journey East to Observe the Eclipse, Dr. J. W. Campbell.

Nov. 8—Ten minute talk, A Few Winter Constellations, Mrs. J. G. Taylor; Experiences of a Lighthouse Keeper, Mr. Robert Chambers.

Dec. 3—Annual meeting; Tycho Brahe, Mr. A. B. McKim.

The special meeting was held on June 6, in honour of a party of British scientists on their way to Fort Rae as a part of the Second Polar Year Expedition. This meeting took place as a banquet.

Oct. 11—The meeting came to order at 8.15 in Room 142, Arts Building. After the reading of the minutes the matter of the annual meeting was considered, and it was decided to hold it in the form of a dinner meeting. Mr. Wilfrid E. Rose then gave a ten minute

talk on Halley's comet, which he had seen in 1910 in South Africa.

Dr. J. W. Campbell, who had journeyed to eastern Canada for the purpose of observing the eclipse of the sun in August, then gave a talk on his experiences and impressions.

Nov. 8—The regular meeting was held in 142 Arts Building at 8.15 p.m. In accordance with the constitution, a nominating committee consisting of Captain Towerton, Miss Gretta Simpson and Dr. E. H. Gowan was appointed, to bring a report at the annual meeting.

Mrs. J. G. Taylor then spoke briefly on a few constellations, including Taurus, Pegasus, Perseus and Auriga. The main topic for the evening was discussed by Mr. Robert Chambers, who delivered an illustrated address on lighthouses of the British Isles, having spent eleven years as a lighthouse keeper in the Shetland Isles.

Dec. 13—This was the annual meeting, held in the banquet room of the Corona Hotel. Three applications for membership were received and approved, viz., those of Miss Margaret O. Buchanan, Miss Evelyn G. Buchanan, and Prof. A. J. Cook.

The reports of the secretary and of the treasurer for the year 1932 were then received and adopted. The meeting agreed to a suggestion that a letter conveying the season's greetings be sent to Mr. J. M. Stagg at Fort Rae, the leader of a party of six British scientists engaged in the Second Polar Year Expedition. This was accompanied by a signed list of those present.

The report of the nominating committee was received as follows:

President—Professor E. S. Keeping.
Vice-President—Mr. M. J. Hilton.
Secretary—Miss Frances M. Fisher.
Treasurer—Dr. E. H. Gowan.
Council—Mrs. J. G. Taylor, Mr. Robert Chambers, Mr. E. N. Higinbotham, Mr. Harold Poole, Dr. J. W. Campbell.

Mr. A. B. McKim then delivered a most interesting address on the life and work of Tycho Brahe, interweaving as well an account of the political and social conditions of the times.

FRANCES M. FISHER,
Secretary.

FINANCIAL STATEMENT OF GENERAL TREASURER FOR 1932

GENERAL ACCOUNT

RECEIPTS, 1932

Cash in Bank, December 31, 1931	$ 61.10	
Grants received	2,750.00	
Publications	654.82	
Members' Fees	1,450.50	
Interest and Exchange	102.03	
		$5,018.45

DISBURSEMENTS, 1932

Publications		$2,637.55	
Public Meetings		77.27	
Library		26.75	
Stamps and Stationery		232.83	
Salary, Assistant Librarian		660.00	
Janitor		12.00	
Rent of Library		120.00	
Grants to Centres		621.35	
Toronto	$141.00		
Montreal	126.50		
Ottawa	106.35		
Victoria	101.50		
London	69.50		
Winnipeg	55.00		
Edmonton	21.50		
Miscellaneous		23.79	
Bank Balance (a/c 4359)—Includes $134.11 of Southam Press Fund		606.91	
			$5,018.45

LIFE MEMBERSHIP ACCOUNT

RECEIPTS, 1932		DISBURSEMENTS, 1932	
Balance from 1931	$261.47	Bonds	$200.74
Bank Interest	4.36	Balance	80.34
Bond Interest	15.25		
	$281.08		$281.08

BUILDING FUND ACCOUNT

Receipts, 1932		Disbursements, 1932	
Balance from 1931	$1,038.01	Bonds	$ 996.96
Bank Interest	14.94	Safe—keeping bonds	2.00
Bond Interest	206.25	Balance	260.24
	$1,259.20		$1,259.20

MEMO OF BONDS HELD BY IMPERIAL BANK FOR SAFEKEEPING

Building Fund Bonds

Description of Bond	Face value	Year of maturity	Rate
D of C TE018682	$1,000.00	1934	5%
D of C NE029210	1,000.00	1941	5%
Can. Perm. Mge. Bonds L15591	500.00	1935	5%
" " " " L15592	500.00	1935	5%
" " " " L13275	500.00	1936	5%
" " " " L20932	500.00	1937	5½%

Life Membership Fund Bonds

D of C R_2TA083071	100.00	1843	5%
D of C R_2TA083072	100.00	1943	5%
Can. Perm. Mge. Bond L20933	100.00	1937	5½%

Southam Press Fund Bonds (Interest in Gen. Acc.)

D of C N_1A013817	$100.00	1936	5%
" N_1A013818	100.00	1936	5%
" N_1A013819	100.00	1936	5%
N S L N_2E008218	1,000.00	1941	5%

J. H. Horning,
General Treasurer.

Audited and found correct
Toronto, January 7, 1933
(Signed) A. R. Hassard, *Auditor.*

VANCOUVER CENTRE

Receipts

Fees for 1932	$ 116.00	
Fees for 1933	14.00	
		$ 130.00

Disbursements

Fees remitted to General Treasurer	$ 87.00	
Bank exchange	.34	
Printing plus cost of die	6.55	
Meeting notices, stamps and envelopes	20.05	
Treasurer's book	.50	
		$ 114.44
Balance in bank, Dec. 13, 1932		15.56
		$ 130.00

Audited and found correct,
Dec. 13, 1932.
J. H. BOWMAN, A. LIGHTHALL } *Auditors.*

J. L. BENNETT,
Treasurer.

VICTORIA CENTRE

RECEIPTS

Cash on hand, November 24, 1931		$ 10.47
Dues received—Arrears	$ 48.00	
For 1932	187.00	
For 1933	10.00	
		245.00
Grant from Toronto		101.50
Receipts from I. A. U. Dinner		66.50
Receipts from sale of group photograph		15.00
Bank interest on current balance		1.80
Exchange on U.S. funds		.98
		$ 441.25

EXPENDITURES

1931 dues sent to Toronto	$ 185.00
Rent and janitor service	28.00
Equipment, repairs and transfer	35.18
Advertising	17.78
Printing and stenography	36.55
Postage and express	19.29
Stationery and supplies	11.15
I. A. U. Dinner	61.23
Tea at D. A. O. to I. A. U. visitors	11.25
Photograph at D. A. O.	7.00
Balance in hand, December 15, 1932	28.82
The Centre is clear of all debt.	$ 441.25

Respectfully submitted,

Audited and found correct,
W. T. BRIDGE, *Auditor.*
December 15, 1932.

H. BOYD BRYDON,
Secretary-Treasurer.

HAMILTON CENTRE

Receipts

Bank Balance	$ 35.87
Membership fees	91.00
Bank Interest	1.28
Proceeds from lecture	19.51
Special donations	43.63
	$ 191.29

Disbursements

Lecture hall	$ 21.00
Expenses of lecturers	9.30
Remittance to Toronto	56.00
Stationery, printing, postage, etc.	52.00
Bank Balance	52.99
	$ 191.29

Geo. E. Campbell,
Treasurer.

W. T. Wingham,
Auditor.

EDMONTON CENTRE

Receipts

Membership fees	$ 96.00
Grant from Parent Society	24.00
Bank Interest	.17
	$ 120.17

Expenditures

Remittance to Parent Society	$ 96.00
Postage and mimeographing	7.20
Account book and Stationery	7.59
Exchange and Express	1.81
Janitor	5.00
	$ 117.60
Bank Balance	2.57
	$ 120.17

E. H. Gowan,
Treasurer.

LONDON CENTRE

RECEIPTS

Bank Balance, Statement of 1931		$ 112.22
Grant from General Treasurer	$ 69.50	
Fees for 1932	138.00	
Bank Interest	3.43	
		210.93
		$ 323.15

DISBURSEMENTS

Fees remitted to General Treasurer	$ 142.00	
Bank Exchange	.46	
Annual Meeting (11/12/31)	31.00	
Annual Picnic	4.60	
Honorarium, Mr. G. Fitchett (Normal School)	2.00	
Honorarium, Mr. H. Billings (London Life Bldg.)	5.00	
Eclipse Expedition	40.00	
Insurance on equipment of Eclipse Expedition	5.00	
Telephone	1.65	
Advertising	12.30	
Flowers	2.00	
Lectures—travelling expenses	9.50	
Secretarial—stamps, meeting notices, etc.	26.43	
		$ 263.94
Balance in Bank, December 9, 1932		59.21
		$ 323.15

G. R. MAGEE,
Treasurer.

Audited and found correct,
December 9, 1932.
(Signed) E. M. S. DALE,
E. B. GRAHAM } *Auditors*

MONTREAL CENTRE

For the year ending October 15, 1932

RECEIPTS

Cash in Bank of Montreal, October 15, 1931			$ 307.45
Members' Fees (96 at $2.00 each)		$192.00	
Grants:			
From General Treasurer, Toronto	$114.00		
" General Treasurer, one-half life membership	12.50		
" McGill University (Dept. of Extra Mural Relations)	50.00		
" McGill Chapter, Society of the Sigma XI	30.00		
		206.50	
Donation		23.00	
Interest on Bank Deposits		12.90	
			434.40
			$ 741.85

DISBURSEMENTS

Membership fees remitted to the General Treasurer (as above)	$192.00	
Lecturers' fees	115.00	
Lecturers' travelling and city expenses, telegrams, lecturers' taxis, etc.	116.11	
Stationary and multigraphing circulars re meetings, etc.	9.58	
Janitor, Lantern Operator, etc.	14.00	
Postage	8.00	
Advertisement re Meetings	3.99	
Eclipse pamphlet for general distribution	5.83	
Handbooks purchased	1.00	
Exchange on cheques	.25	
Total disbursed		$ 465.76
Leaving Balance on hand, October 15, 1932, of		$ 276.09
Consisting of cash on hand of	.55	
And cash in Bank of Montreal	275.54	

Respectfully submitted,

A. VIBERT DOUGLAS,
Treasurer.

Audited and found correct
O. A. FERRIER, C.P.A.
(*Certified Public Accountant*).
Montreal, October 17, 1932.

OTTAWA CENTRE

I beg to submit herewith the financial statement of the Ottawa Centre of the Royal Astronomical Society of Canada.

Balance in Bank on December 19, 1931	$121.30	
Amount collected in dues	147.00	
Contribution from Head Office	106.35	
Interest on deposits	3.34	
		$ 377.99
Amount sent to Head Office	$107.00	
Expenses connected with lectures	31.50	
Printing and stationery	25.21	
Postage, exchange and miscellaneous	14.55	
Advertising	41.00	
Balance in Bank and on hand, Dec. 19, 1932	158.73	
		$ 377.99

Of the outstanding dues three members owe dues for 1931 and 1932 and eight others owe dues for 1932 only.

A. W. GRANT,
Treasurer.

TORONTO CENTRE

RECEIPTS

Balance from statement, 1931	$ 166.03
Grant from General Treasurer	141.00
Refund from "The Star"	1.30
	$ 308.33

DISBURSEMENTS, 1932

Rent to University of Toronto	$ 60.50
Lecture expenses	21.30
Printing announcements, etc	43.70
Harvard telegrams	13.32
Balance in bank, Dec. 13, 1932	169.51
	$ 308.33

(Signed) WM. WUNDER,
Treasurer.

Audited and found correct
January 7, 1933.
(Signed) A. R. HASSARD, *Auditor.*

WINNIPEG CENTRE

Year ending Dec. 14th, 1932

RECEIPTS

Balance statement of 1931		$ 48.35
Grant from General Treasurer	55.00	
Bank interest	1.01	
Cash receipts from Sir Frank Dyson lecture	25.00	
Subscriptions as follows:		
Fees for 1930	2.00	
Fees for 1931	10.00	
Fees for 1932	72.00	
Fees for 1933	6.00	
		171.01
		$ 219.36

DISBURSEMENTS

Advertising	$ 32.16	
Printing	16.38	
Operation of lantern	12.00	
Honorarium	6.50	
Expenses Sir Frank Dyson dinner	7.25	
Bank exchange	.54	
Postage and stamps	14.62	
Cheque to the National Council of Education	25.00	
Flowers	11.00	
Fees remitted to General Treasurer	92.00	
		$ 217.45
Balance in Bank, Dec. 14, 1932		1.91
		$ 219.36

J. H. KOLB,
Treasurer.

Audited and found correct,
Dec. 13, 1932.
(Signed) JAMES HOUSTON
MRS. E. L. TAYLOR } *Auditors.*

REVIEW OF PUBLICATIONS

Lehrbuch der Astronomie von Elis Strömgren und Bengt Strömgren. Pages viii, 555; 6¾x10 in.; 186 figures. Berlin: Julius Springer, 1933. Price, RM 32 (bound).

This book, by the well-known Copenhagen astronomers, is a translation and enlargement of the Danish edition which appeared in 1931, and the latter was based upon the text by Mohn and Geelmuyden, for a long time well known in northern Europe.

It is not of the "popular" type of astronomical books nor is it severely technical, but is a combination of the two sorts. First, a subject is introduced by giving the fundamental facts relating to it with a simple diagram or two and then follows a moderately complete mathematical treatment. Included is a fairly comprehensive outline of the mathematical handling of two-body, three-body and *n*-body problems; of the perturbation problem; of the atomic mechanism of emission and absorption, with the deduction of the formulas of Planck and Stefan; of the determination of the elements of the orbits of double stars; and of other recent astrophysical theory.

After an introduction of 26 pages, spherical astronomy is treated in 94 pages; then follows a discussion of astronomical motion and some connected problems in 82 pages; then 60 pages are devoted to the mathematical treatment of the problems of two or more bodies; after this comes the solar system, 59 pages, and stellar astronomy and astrophysics, 172 pages. At the end are formulas and methods of computation.

The large pages are simply filled with information, and researches down to July, 1932, are included. The language is straightforward and simple, and the printing is in the superior style of the house of Springer.

C. A. C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Two Personal Notes

Dr. V. M. Slipher, director of the Lowell Observatory, has been awarded the Royal Astronomical Society's gold medal for 1933 for his spectroscopic researches on planets, stars and nebulas. He will deliver the George Darwin lecture this year.

Dr. John Jackson, chief assistant at the Royal Observatory, Greenwich, has been appointed director of the Royal Observatory at the Cape of Good Hope.

British P.O. and 24-hour Time

There is a bill before the British House of Lords to legalize in the British Post Office the use of hours numbered from 0 to 24, as has been the custom in some countries on the European continent for years. It is supported by Sir Frank Dyson and would certainly bring simplicity and precision into timetables and other announcements involving specifications of time. It may be recalled that about fifty years ago the 24-hour system was tried on Canadian transcontinental trains but was given up. The present writer thinks it a very useful method of stating time, easily understood by any intelligent person.

Multiple Images on Photographs of the Sun

In the January Journal a suggestion was offered as to the cause of certain images found on photographs of the partially eclipsed sun. It was that the ordinary bright image on the film acted as the source of rays of light which were reflected from the rear face of the objective. This may be one cause but it certainly is not the only one, as is shown in a communication from Mr. E. H. Darling, the well-known Hamilton engineer. On some films he obtained five images and they showed the shape of the diaphragm. Mr. Darling says: "I find that these ghosts are due to the repeated reflection of the diaphragm between the surfaces of the rear or inside lens and there are probably other less noticeable reflections, such as

round dots, from the front lens. That such reflections exist may be seen by holding either lens twelve or eighteen inches from the eye toward a bright light, keeping the eye out of the main focus and shaded from the light,—series of images will be seen arranged as in the photographs. When the lenses are combined the series become very complex and certain bright dots are noticeable.

"The rays which you mention are also found on the enclosed prints and there are some reasons for believing that they are the overlapping edges of pairs of very large images of the diaphragm. [The Editor questions the correctness of this explanation.]

"If the above theory is correct then these ghosts are always present when a compound lens is used and it may be due to them that there is always a halo around bright lights near the centre of a picture."

A Fine Lunar Halo

A splendid lunar halo was seen for about two hours on the evening of February 8, 1933. As observed by the present writer at 9.45 E.S.T. in Toronto, there was about the moon a "primary" circle of diameter about 22° distinctly coloured with red on the inside. The area within this circle was dark blue. Outside of this was a "secondary" circle of twice the diameter seen only in its lower portion. There were signs of colour in it also, red inside, and the area between the two circles was darker than outside the larger one. A friend reports seeing a tangent arc at the lower side of the outer circle. Then there was a circle having the zenith as centre and its circumference passing through the moon, although it could not be detected within the primary circle. No colour observed in this circle, and no moon-dogs or bright spots spaced 120° apart as in a solar halo. It was interesting to observe this zenith circle contract as the moon's altitude increased. The writer received an excellent report from Master Herbert C. White (age 14) of Welland, Ont. His diagram for 8.55 shows the zenith circle distinctly larger than that seen an hour and again an hour and a half later.

Henry Norris Russell, President of the A.A.A.S.

The new president of the American Association for the Advancement of Science is Professor Russell, well known wherever astronomy

is cultivated. In "Science" for February 3, 1933, appears a sketch of his life by "J.Q.S.", which is given below.

A truly encyclopedic knowledge of physical science is impossible at present, but Henry Norris Russell's scope approximates that. In the varied science of astronomy there are few fields to which he has not contributed. To physicists he is known for brilliant work in classification of spectra. He is a stimulating lecturer, to technical and lay audiences alike, and general readers are in his debt for regular accounts of astronomical progress. He took a leading part in preparing a general astronomical text. His acquaintanceship with scientific men is of the widest; on many committees he has strengthened liaison between diverse fields and assisted in formulating policies. Nor do these professional matters by any means exhaust his sympathy and energy.

He was born at Oyster Bay, New York, on October 25, 1877. His father, Alexander G. Russell, was born in Nova Scotia, of Scottish stock. His mother, Eliza Hoxie Norris, came of a line of New England sea-captains, and was born in Para, Brazil, where her father was temporarily resident as American consul. Both he and her mother showed strong interest in exact science.

At the age of 12, Henry Norris Russell came to the Princeton home of his mother's family. He took his A.B. at Princeton University in his twentieth year, late in the "golden nineties", which—it would now appear unjustly—have not been considered there a period of high intellectual attainment. Receiving his Ph.D. in astronomy from the same institution (under Young) in 1900, he spent 1902 through 1905 at Cambridge, England, first as research student at King's College, then as Carnegie research assistant at the observatory. He was recalled to Princeton as instructor in astronomy (1905) by E. O. Lovett, then head of the department; and in spite of other nations he remains at Princeton, as research professor, chairman of the department of astronomy, and director of the observatory. Among graduate students whom he and his colleague of many years, Professor Raymond Smith Dugan, have instructed are Joy, Shapley, Menzel, Dunham. Since 1921 he has been borrowed from Princeton for several months of every academic year by the Mt. Wilson Observatory as research associate.

Russell first attained general recognition by his work in the field of stellar constitution and evolution, about 1913. Starting from Hertzsprung's differentiation of red stars into giants and dwarfs, he organized the luminosity-type diagram —which shows relations between intrinsic brightnesses and the surface temperatures of stars. He gave physical interpretation to this now well-known picture by following lines suggested many years before by H. Lane and Sir Norman Lockyer. Subsequent developments in atomic physics, which could not have been foreseen, have invalidated Russell's theory, but the diagram itself has exercised controlling influence on the advance of stellar physics. He has continued contributing to this now very complex subject, and in the first Maiben lecture at the Atlantic City meeting of the A. A. A. S. he presented a critical summary of current knowledge. An earlier summary was given in a course of Lowell lectures in 1931. Early in 1923, as the direct result of arranging demonstrations of spectra for an undergraduate course, he became interested in the expanding subject of the

relation of spectra to atomic constitution. In collaboration with F. A. Saunders he attributed the anomalous terms in the spectra of the alkaline earths to the joint action of two electrons, initiating the interpretation of complex spectra. He has taken an extensive part in the analysis of such spectra. Another series of papers deals with astro-physical applications of these principles and of ionization theory, culminating in a study of the composition of the sun's atmosphere (1929) and in studies of stellar spectra made in collaboration with W. S. Adams and Miss Moore.

In positional and dynamical astronomy, mention may be made of his work on stellar parallax (published in 1911); on the photographic determination of the moon's place; and on dynamical parallaxes of double stars—the latest list by Russell and Miss Moore includes 1,777 objects. Photometric interests are represented by a discussion of the albedo of the planets and satellites (1916) and a series of papers on the determination of the elements of eclipsing variables (partly in collaboration with Shapley, then a graduate student). His war-work on airplane navigation also may be mentioned.

As first Terry lecturer at Yale, under the title "Fate and Freedom," Russell exhibited what future historians of the well-worn relationship of religion to science may describe as a last stand of the Calvinistic mechanist just before old dykes broke and the rising tide of indetermination blotted out his trenches—but he retires with honor since his thesis was that mechanism didn't matter. He has from time to time preached sermons in churches of various denominations.

Russell's honorary degrees are from Dartmouth—D.Sc., 1922—Louvain—Doctor, 1927—and Harvard—D.Sc., 1929. His medals include the gold medal of the R. A. S., the Lalande medal, the Draper, the Bruce and the Rumford. He served as vice-president of the mathematics-astronomy section of the A. A. A. S. in 1918, and as president of the American Philosophical Society in 1931-1932. He is a member of numerous other scientific societies and a foreign associate of the Royal Astronomical Society; he is chairman of the committee on stellar spectra of the International Astronomical Union, and a member of its committees on double stars, stellar parallaxes, stellar statistics, solar spectroscopy, stellar constitution and notations and units.

His work has been distinctly theoretical rather than observational. In 1908 he married Lucy May Cole, of New York; they have four children, of whom three are now in college. Travel is for him a ruling passion and he spent a sabbatical year with his family in Egypt and the Near East without visiting an observatory or reading an astronomical periodical.

C.A.C.

MEETINGS OF THE SOCIETY

AT LONDON

January 13, 1933.—The regular meeting of the London Centre was held on this date, the president, Mr. George Gunn, in the chair. There were 34 members present.

The speaker for the evening was Mr. E. H. McKone, B.Paed., of the London Normal School. His subject was "Astronomical Terms Everyone Should Know". He began with such familiar terms as "up", "down", "east", "west", that have a meaning relative only to the observer on the earth.

Measurement by degrees was then introduced, the speaker emphasizing the fact that any angle may be subtended by the arc of a large or small circle. The division of the circle into 360 parts was first used by the Babylonians, probably to correspond with the number of days in a year.

The "Horizon System" for location of heavenly bodies was taken up, and the terms "zenith", "nadir", "azimuth", "altitude" were developed. The system most universally used by astronomers is the "Equatorial System".

As a starting point the plane of the earth's equator was produced to meet the sky and this gave the Celestial Equator. From this circle distance north and south is measured. This distance is known as "declination". The Celestial Equator may be located in the sky at the present season by means of Orion's Belt.

To describe the position of a heavenly body, another set of lines is necessary to measure east and west in the sky as the meridians do on the earth. The point where the sun's yearly path about the heavens crosses the Celestial Equator is taken as the "Greenwich of the sky". This point is called the "Vernal Equinox", and through it from the north to the south celestial poles runs the Equinoctial Colure. Later in the evening it was pointed out that this colure may be found by drawing a line from Polaris through the westermost star of the Big W of Cassiopeia and just within the eastern boundary of the Square of Pegasus. By means of Hour Circles, 15 degrees apart, crossing the Celestial Equator at right angles, distance east of the Vernal Equinox may be measured. This distance is called "Right Ascension". The speaker showed diagrams and pictures to help visualize these lines.

In speaking of the revolution of the planets around the sun, another system of location is used. To illustrate this "Ecliptic System", a paper zodiac was supported on upright wires and a planetarium used to show the meaning of such terms as "conjunction", "opposition", "transit", etc.

At the end of the lecture a typed list of "Useful Terms in Astronomy" was handed to each member.

Dr. Kingston then gave a short talk on Occultations for 1933 and what

constitutes a suitable one for observation. There are no very spectacular ones to be seen this year. The phenomena for January as seen in the HANDBOOK, was reviewed.

Questions and discussions at the close showed the deep interest the members took in the subjects for the evening.

N. MORRIS, *Secretary-Treasurer.*

AT TORONTO

January 31, 1933.—The regular meeting was held at 8 p.m., Mr. R. A. Gray being in the chair.

Moved by Mr. J. R. Collins, that, as Dr. J. B. Fraser, one of the auditors, was unable to act and had tendered his resignation, the treasurer's statement for 1932, as audited by Mr. A. R. Hassard, the continuing auditor, be accepted. Carried.

The resignations of Dr. W. M. Wunder, treasurer, and Mr. S. C. Brown, recorder, were accepted.

Mr. J. E. Maybee was appointed treasurer, and Mr. Gordon Hepburn, recorder, for the remainder of the year.

Mr. F. L. Troyer then outlined the astronomical phenomena for the following two weeks. Mr. Collins referred to letters received from the eclipse expeditions of the University of Toronto, the Dominion Observatory, and Georgetown College Observatory, stating that their observations of the duration of totality agreed within a second or so of the measurement of 101 seconds made by this Society's group and by the French Government astronomers at Louiseville, Quebec.

Mr. Collins then took the chair, and Mr. R. A. Gray spoke to the audience on "Copernicus". Copernicus was born in 1473, at Thorn in Polish Prussia, and studied in Cracow and in Italy. Although holding the office of a priest at Frauenberg, he was best known as a mathematical astronomer. His few astronomical observations were neither accurate nor of very great value, and he is better noted for this theoretical considerations. Ptolemy's "Almagest", and the system of a geocentric universe has been accepted for fifteen centuries. Copernicus, however, would not accept this idea since it failed to explain the retrograde motions of the planets and would place all the stars at the same distance.

Mr. Gray, with the aid of diagrams on the screen, outlined the development of the various concepts of the geometrical structure of the universe from the time of Ptolemy and Eratosthenes until that of Copernicus and the introduction of the heliocentric system.

Mr. Gray then returned to the chair, and Mr. Collins conducted the constellation study, the topic being "Orion". After some discussion, the meeting adjourned.

F. L. TROYER, *Acting Recorder.*

The Royal Astronomical Society of Canada

OFFICERS FOR 1933

Honorary President—Mgr. C. P. Choquette, M.A., Lic.Scs., Montreal.
President—R. K. Young, Ph.D., Toronto.
First Vice-President—Lachlan Gilchrist, M.A., Ph.D., Toronto.
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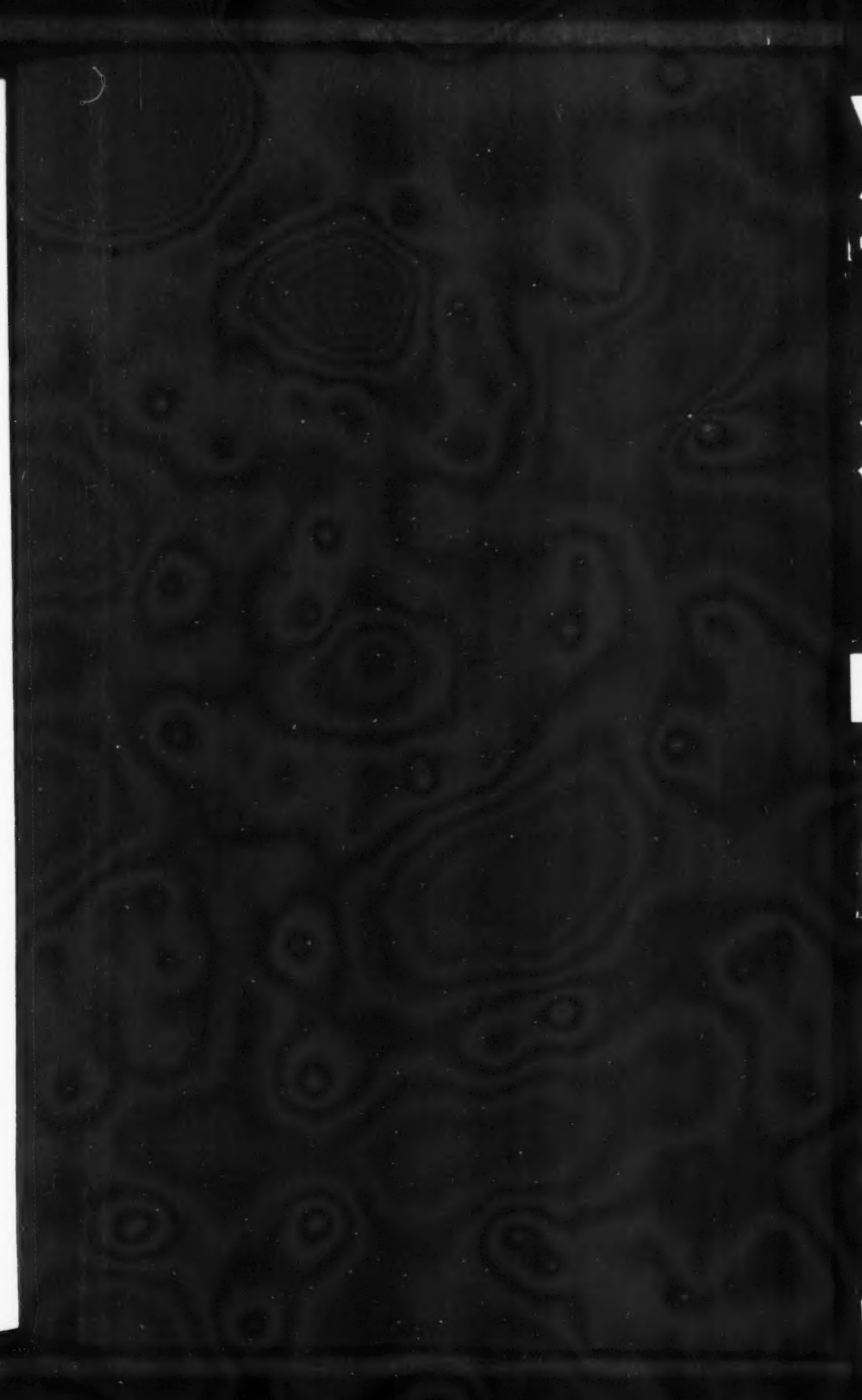
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